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USE OF THE BATHYTHERMOGRAPH IN AN ARCTIC SEA

by

B. S. Zalogin and M. S. Edel'man

Recently our industry has successfully undertaken the production of several modern oceanographic instruments, in particular bathythermographs (BT's), which are now used very extensively in expeditionary investigations and by the searching vessels of the fishing industry. However up till now, the operational experience with the bathythermograph is still unsatisfactory and therefore each new operation of a methodological nature can be of definite interest. In this article an experiment on the use of the bathythermograph (BT) under arctic sea conditions is examined.

In the joint expeditionary operations of the Chair of Oceanography of the Moscow State University and the Arctic Scientific Research Institute (Arkticheskii nauchno-issledovatel'skii institut) in one of the arctic seas the bathythermograph was used. This was the series instrument "TB-52", made by the Moscow Hydrometeorological Instrument Factory, without any alterations and improvements; the microscope slides were in their factory packing. Reversing thermometers were operated simultaneously with the BT. In all (during the operation) 41 bathythermograms were obtained, including 9 at sea.

In working with the BT at first an electric winch was used, fixed on the portside in the center of the ship, and for the thermometers a hand winch was used, fixed on the opposite side. The bathometers and BT's were lowered at the same time. At the first six stations the BT was lowered several times to determine the most favorable operational regime (rate of lowering and raising, etc.) and to determine the extent of agreement of BT and thermometer readings.

At the first station, where the BT was lowered three times at the first winch speed (descent 0.36 m/sec, ascent 0.46 m/sec) good agreement between the BT and thermometer readings was found (figure 1), especially in the first and third descents, when the instrument was kept immersed 0.5-1 min at the surface of the water. During the second lowering when it was not kept in this position, the agreement between the BT and thermometer readings was

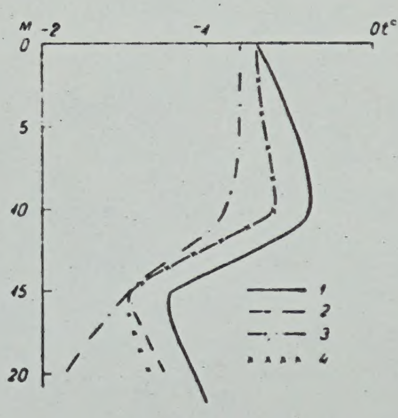

Figure 1. Temperature distribution curves. 1 - Using the thermometer. 2 - Using the BT, 1st descent. 3 - Using the BT, 2nd descent. 4 - Using the BT, 3rd descent.

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considerably poorer. The mean deviation value of the BT readings from the thermometer readings during the first and third descents was 0.2°, i.e., corresponding to the specified accuracy of the instrument. In the second descent the deviation value reached 0.4°, whence in this case even the shape of the curves differed somewhat from the typical.

At the second station the instrument was lowered twice: once at the first speed and once at the second (descent 0.46 m/sec, ascent 0.75 m/sec). Here also satisfactory agreement between the BT and thermometer readings can be noted. Thus, in the first descent the mean difference of the readings was 0.13° and in the second 0.18°.

At the third station the instrument was lowered six times: three times at the first speed of the winch and three times at the second speed. In all these cases the readings of the BT were very close to the readings of the thermometers. It was noted, however, that the best agreement of the measurement results is found in the instrument descent at the first (least) speed of the winch when it is kept momentarily immersed at the water surface, which is explained most likely by the inertia of the instrument.

Beginning with the fourth station the BT was lowered with the hand winch, with which the thermometers were lowered, whence at the fourth, fifth and sixth stations two descents were carried out - one before and one after the operation with the thermometers. Subsequently the instrument was used at each station once before the lowering of the thermometers which made possible the most accurate placing of the bathometers to reveal the structure and to determine the boundaries of the discontinuity layer accurately. In three instances, due to the negligence of the lookout technicians, the BT was used after the operation of the thermometers. In these instances the curves of vertical temperature distribution, constructed on the basis of BT and thermometer readings, show the greatest difference in the very discontinuity layer. At these stations bathythermograms obviously give a more accurate picture of the type of temperature distribution.

In all cases of work with a BT graphs of the vertical temperature distribution were constructed on the basis of the BT and reversing thermometer readings. The mean temperature values are plotted on the graph where the bathythermograms showed a temperature lag. These graphs (several of them are given in figure 2) showed good agreement between BT and thermometer measurements. The mean difference, calculated on the basis of 32 bathythermograms obtained at the oceanographic stations, is 0.19°, whence in the overwhelming majority of the cases the BT showed a lower temperature than the thermometers.

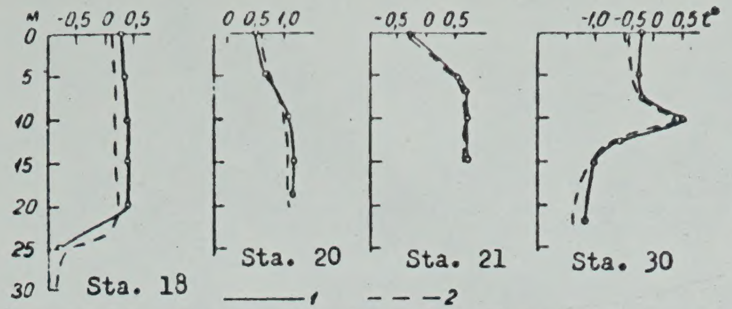

Figure 2. A group of temperature distribution curves at various stations: 1 - using a thermometer, 2 - using a BT.

Besides the operations at the stations, when the ship was drifting, nine BT descents were made at sea in the region with depths greater than 40 m. Operations were carried out with a "North Pole" ("Severnyi polius") type winch provided with an electric motor and mounted in the middle part of the ship. About 200 m of steel cable 3 mm in diameter were wound on the drum of the winch. It had free play.

Since the preliminary attempts to lower in operation a 30 kg metal weight showed there is a danger that the instrument will be drawn under the keel and that the cable will run afoul of the propeller, an apparatus was constructed for lowering the BT at sea from the stern using the electric winch without moving it to another place. A diagram of this apparatus is shown in figure 3 and needs no explanation.

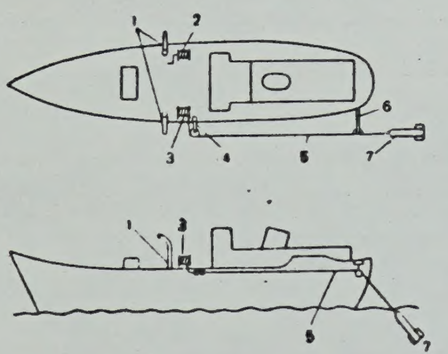

Figure 3. Diagram of the setup for lowering a BT at sea. 1 - davit. 2 - hand winch. 3 - electric winch. 4 - projection piece with pulley. 5 - cable. 6 - projection piece with counter. 7 - bathythermograph.

The distance of the computer unit from the rheostat which controls the winch and from the pilot house made it necessary to select two men for communication. Thus a total of four men participated in the operations: one worked directly with the instrument, the second operated the winch, the third was on the deck and transmitted the signals from the instrument to the winch, and the fourth, standing on the spardeck, provided communication between the instrument and the pilot house.

The instrument was lowered three times each at low (4.5 knots), medium (7.2 knots)

and full (9.8 knots) speed. During the entire time of the observations depth soundings were made periodically with an echo sounder (the depths were near 40-45 m at all times). When lowering the BT the computer unit was set at zero at the moment the instrument was completely immersed in water. It was kept in this position 30 sec and then freely lowered. The rate of descent and ascent were checked by a stopwatch.

Table I gives some data on working with a BT at sea. As is known, there is an orientation table for calculating the length of cable to be payed out when lowering the BT to a given depth in the book of instructions accompanying the BT. Since in our case we worked at slight depths, we had to extrapolate the table in the instruction book. But the values obtained in this way disclosed very considerable deviations from those depth values recorded by the BT. A comparison of the data in Table I with the extrapolated values confirms this quite obviously.

Table I

Descent No.	Cable payed out (m)	Angle of cable inclination (°)	Depth of immersion (m)	Instrument descent rate (m/sec)	Instrument ascent rate (m/sec)	Ship speed (knots)
1	48	70	14	1.5	0.99	4.5
2	50	70	20	1.5	0.99	4.5
3	60	70	28	1.5	0.99	4.5
4	60	70	17	2.6	0.75	7.2
5	67	77	20	2.6	0.75	7.2
6	58	75	10	2.6	0.75	7.2
8	57	80	16	3.2	0.6	9.8
9	61	82	16	3.2	0.6	9.8

Note: In the seventh descent the slide had no base line and a very weak trace so no readings could be taken.

Thus, in the first three cases of operating the BT at sea the given depth of immersion of the instrument was 30 m. According to the values of the table in the instruction book at a speed of 5 knots (in our case 4.5 knots) 330 m of cable should be payed out to lower the instrument 200 m. Consequently, the length of cable payed out to immerse the instrument 30 m should, according to calculation, be 50 m. However, when 50m of cable were payed out, the instrument reached a depth of only 20 m. Thus, the error in calculating the depth of immersion of the instrument was more than 30%. During the second lowering of the instrument at this same speed, when an additional 10 m of cable were payed out, the instrument reached a depth of 28 m.

At the medium speed of the ship (7.2 knots) at the same given depth of immersion, according to analogous calculations 57 m of cable should be payed

out. Actually when 58 m of cable were payed out the instrument reached a depth of only 10 m, with 60 m of cable a depth of 17 m, and with 67 m of cable a depth of 20 m. The error in the calculated depth of immersion in this case exceeded 70%. The difference between the actual depth values and the computed when working at full speed (9.8 knots) are also great.

This leads us to the conclusion that the table in the instruction book should not be extrapolated when working at slight depths. Obviously, it is necessary to carry out additional experimental investigations and to compile a special table for shallow water regions.

Figure 4 gives several bathythermograms recorded by the instrument at sea. They give a picture of the temperature distribution with depth at sea between stations and are valuable supplementary material for studying the heat budget of the sea.

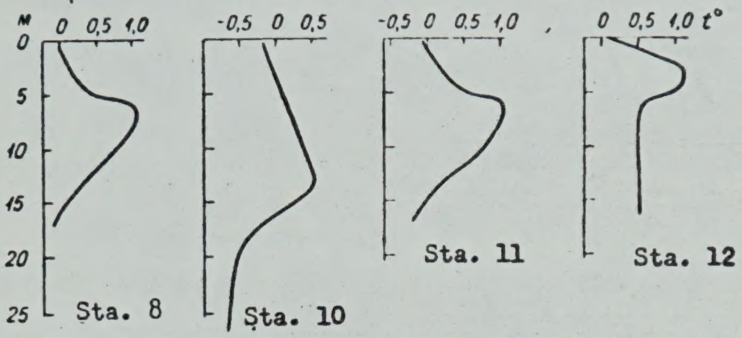

Figure 4. A group of temperature distribution curves obtained at sea.

Thus, during the expeditionary operations we were convinced of the real possibility of extensive use of the BT in carrying out oceanographic investigations in the arctic seas both at stations and at sea. The instrument worked well in low temperature waters which dispels the doubts expressed earlier on the applicability of the Soviet version of the BT in cold waters.

The use of this instrument makes it possible to survey in a brief period of time extensive areas of the arctic seas and thus to obtain a detailed picture of the structure of the temperature discontinuity layer.

It should be assumed that the time has come to equip all arctic observatories, ice patrol ships and icebreakers with BT's. This instrument, quite simple and convenient to use, should play a role in the farmost study and assimilation of the seas of the Soviet Arctic.

In conclusion we should like to express the wish that the Scientific Research Institute for hydrometeorological instrument construction will build an

instrument model with a smaller depth range (0-25 m, 0-50 m) in order to increase the scale of recording and the accuracy of the readings when working in shallow seas and when studying the upper active layer of the ocean.

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